Sustainable Seas Expeditions
Protocols for Site Characterization

This purpose of this document is to convey two survey methods that may be appropriate for submersible pilots operating DeepWorker. It is intended for pilots who have not already chosen a survey technique for their dives or who have found that their first choice did not allow them to adequately complete their mission. Either technique may also be appropriate for ancillary data collection in the event that time allows observations beyond planned activities.

These are only two of numerous protocols that could be used, but are presented because they have proven reliable for previous investigators using subs and ROVs. Either may be modified to meet specific needs. Your selection depends on your goals for the mission and the extent to which you require data compatible with previously collected information from the sites of interest. Each method has both advantages and disadvantages, which will be discussed at the end of the document.

Operational Considerations

When selecting a sampling strategy, one must consider mission goals, required sampling precision, required accuracy of positioning and navigation, the likelihood and effect of equipment malfunction, familiarity and expertise of the pilot with the sub's systems, and the abilities of other pilots who may be asked to acquire comparable data on later dives (e.g. at locations selected for repetitive monitoring or at other stations for which similar characterizations are desired).

With regard to positioning accuracy, there are multiple levels of accuracy loss that are involved with calculating a submersibles location. That is, the normally reliable accuracy of GPS is diminished by uncertainty added by calculating the sub's location relative to the ship in three-dimensional space. Theoretically, it may be possible to calculate DeepWorker's position to within about five meters. It is likely, however, that thermoclines, ship movement, electronic and sonic interference, equipment malfunction, and other factors will reduce accuracy on occasion. Thus, pilots should not expect to be able to return to unmarked or non-descript locations with any greater certainty than this positioning accuracy. Neither should they expect to navigate along desired transects with any greater precision. The actual accuracy of these systems under field conditions, or course, remains to be determined.

Also, recall from training that, at least presently, certain electronic equipment aboard DeepWorker seems to affect other electronic gear. If one piece of equipment is turned off, breaks down, or its battery dies, other equipment may be affected. If the compass is one of these instruments affected, navigation will be even less precise.

Recon/Census Method

The following site characterization protocol combines methods that have been used in previous submersible, ROV, and scuba diver surveys to describe and, to some extent, quantify invertebrate and fish assemblages in a variety of habitats (e.g. high relief reefs, boulder fields, sandy bottoms). It can be used to characterize one of more sites, or compare biotic and abiotic features. In addition to traditional qualitative site characterization, the method can be used for monitoring, and for assessment of human impacts. It can also be applied during dives that are otherwise largely exploratory in nature.

When conducting multi-site comparisons, the recon/census method is most effective when observations are conducted by a single observer, but when followed closely, multiple observers can achieve comparable field information quality. Follow-up analysis of video and audio records by a trained investigator can further reduce observer differences.

At each site selected, data are acquired using video imagery, still cameras, and voice descriptions of observations. Emphasis is placed on collection of high quality video imagery in order to record behavior and diagnostic characteristics of animals and plants, but still photographs are taken frequently because their higher resolution is useful for organism identification. Transits through survey sites may be either systematic or random during initial surveys. Reliable information about temporal change can be obtained by conducting surveys along semi-repeatable transects established during initial dives. For small features or locations of particular interest, temporally repetitive descriptions based on thorough surveys of individual features are also appropriate. In either case, relocation of study sites is critical and markers would be helpful (markers may be natural or artificial).

Data collection should involve both verbal and written records. Written data are required to assess relative abundance for the taxa observed. This is done by recording the taxa encountered, listed in order of their appearance, followed by an assessment of relative abundance, which is made soon after completion of the site survey (see below). Similar results can be obtained without written records by reviewing video tapes immediately following dives and listing species and relative abundance at that time, but this requires a commitment of time that may not always be available. Which approach will be more appropriate depends on how difficult it is to compile written records while piloting.

Dives begin by descent and location of a desired station, generally determined prior to the dive. Stations may be selected based on review of bathymetric records, based on prior knowledge of the site, or by other means. Once on station, the pilot should begin verbally recording information on physiography, benthic assemblages, and pelagic communities. In fairly diverse habitats, the observer should focus on each of these categories separately. Duplicate videotape and audiotape records should be made.

Observers' verbal comments during the dives should be nearly continuous, and should include an initial record of date, time, dive number, pilot, location and mission, followed by very frequent reference to depth and time. Site descriptions consist of a habitat descriptor (using standardized terminology), organism identification (either formal or informal, such as “red tube sponge”), a qualitative descriptor of relative frequency for each taxon, quantity (where appropriate), community descriptions (e.g. cover, distribution, vertical zonation, apparent ecological controls, habitat affinities), and other comments relating to the observation (e.g. behavior, evidence of human impacts). Relative frequency descriptors for taxa at each station are modifications of those used by Starck (1968) for fish abundance at Alligator Reef, in Florida, Dennis (1985) and Dennis and Bright (1988) for fish abundance on hard banks in the northwest Gulf of Mexico, Gittings (1992) for invertebrates and fish on a variety of substrates in the northeastern Gulf of Mexico, and the Reef Environmental Education Foundation (REEF) for reef fish censuses in the Caribbean and coastal U.S. Pacific. The category names and numerical constraints are taken directly from the REEF Roving Diver Survey method, which is similar to the survey techniques proposed here and because REEF and The Nature Conservancy have established a large, web-accessible database that is proving both reliable for reef assessment and useful for management. The descriptors are:

Single — single individual or colony; comparable to *“Rare”* classification used by others, indicating seldom observed, or a very small percentage of observations at a site.

Few — 2-10 individuals or colonies; comparable to *”Occasional”* classification of others, indicating sporadic observations, usually at irregular intervals, or, for example, a single small school of fish.

Many — 11-100 individuals or colonies; comparable to *“Frequent”* or *“Common”* classification of others; encountered regularly; seen in a large portion of their preferred habitat at a survey site.

Abundant — >100 individuals or colonies; a regularly encountered species observed in high numbers, representing a high percentage of observations.

The relative frequency of each species recognized at each station should be estimated after each site survey, and modified, if appropriate, after video tape and photograph review. This can be done for each site visited, or for each habitat type present at each station. Some stations, for example, will contain a number of habitat types (e.g. bank tops, bank faces, low surrounding features, debris fields, and surrounding sandy bottom areas), each of which harbor different associated communities.

There are ways of analyzing relative abundance information statistically. For example, each species can be assigned a number between 1 (*Single*) and 4 (*Abundant*), based on its relative abundance. A measure of invertebrate or fish community development at each station is the sum of relative frequencies for each of the taxa present. Various other analysis techniques for such data are also available (e.g. dominance measures, sighting frequencies, diversity and similarity indices, and others) and more sophisticated evaluations, such as those related to trophic structure (Pattengill et al., 1997) are also possible. Temporal and spatial comparisons are then feasible.

Transect Protocols

For pilots without adequate taxonomic skills to do in situ descriptions of assemblages, or in the event that the goal is simply to record specific locations for later analysis, video transects can be flown by DeepWorker. The primary keys to acquiring reliable data using transects are maintaining constant speed, altitude, and track, and attention to detail with regard to annotating tape records and monitoring time.

At this point, there is no altimeter on DeepWorker, so the pilot must eyeball altitude above the bottom. Consistency (probably about 0.5 m) will simply require experience. The same is true for speed. There is no speedometer on DeepWorker. One way to determine whether speed is adequate (probably about 1/4 to 1/2 knot) is to look at the video screen and ensure that high quality images are being obtained. The sub will have a compass, but it is not yet known how easy it will be to follow a desired heading.

In order to assure consistent areal coverage on video transects, the most effective technique is to operate from one known location to another. In practice, this will likely require installation of station markers. In the absence of markers, timed transects along a selected compass heading are acceptable, but less consistent due to the difficulty of maintaining a known and constant speed. In either case, coverage of the entire transect length should require less than the time between life support checks (15 minutes). We suggest ten minute transects in order to have time to organize equipment (recorders, videotapes, audiotapes), check settings, and annotate tapes.

Desired speed depends on the area of coverage by the video camera. The larger the area, the faster the sub can travel. With tight coverage, speed must be kept very low in order to acquire high quality video. The final selection of speed and camera angle will have to be determined after we see the final configuration of the sub and have a chance to evaluate the video systems (height of camera, down-angle, lens angle of acceptance).

There are a number of other factors that should be considered when deciding how to conduct video transects. Transects should be along isobaths, if possible. Downhill and uphill transects are difficult to fly with constant altitude. They should also be into the current so that the pilot can control speed and heading. Camera angle is critical to maintaining consistent coverage. If the camera is attached to a pan-and-tilt mechanism, the pilot must ensure that the down-angle is at the desired position. If there is no such mechanism, the pilot must still ensure that the camera is secure before the dive and that it is not bumped out of position on deployment or during the dive.

To begin a transect, the pilot locates the zero position and readies the sub by turning to the proper heading. Then he or she assures that the appropriate tapes (pre-labeled) are inserted in the video and audio recorders. Both are turned on at the same time along with the laser pointers and video lights, and the date, time, pilot, location, depth, and transect number are recorded. The video camera should then be checked for proper angle and lighting, and the zoom should be at wide angle. If still photos are to be taken, be sure that all preparations for the camera and strobes are made.

Time at the start of the transect should then be noted (actually, a timer on a watch set for ten minutes is a more convenient way to monitor time). The video camera should be run continuously during the transect. The pilot should be sure to record depth frequently, as no information other than time and date are recorded on the video tape. Information from the audio and videotapes will also be useful in annotating still photographs. The pilot should also be careful to closely monitor the time in order to trigger the still camera at the appropriate times (without a bulk loaded still camera, only about 28 shots can be taken on any single dive, so these need to be apportioned among the transects, with a couple shots remaining for surprise observations at the end of the dive).

Navigation during each transect may be possible from either the sub's tracking/ navigation system or the sonar. At 1/4 to 1/2 knot, ten minute transects will cover between 250 and 500 feet. If the ends of the transects are marked with sonar reflecting markers, the sonar could be used. Otherwise, a way point may be added to the screen of the navigation system and approached from a desired heading. In either case, repeatability will be limited. Identically repeated transects will not be possible.

If the pilot is capable of identifying fishes, a belt transect can be performed to quantify fishes at a station. The belt transect method for quantifying fish abundance is adapted from Stein et al. (1992) and follows the previous general transect protocols with some additional modifications. The pilot should perform 30-minute transects (though required life support readings may interrupt the interval of force changes in transect duration) and identify, count, and estimate lengths of all fish encountered in a 2m wide belt in front of the submersible along the transect. The bottom type will also be characterized along the transect. Transects should be performed at least one hour after sunrise and prior to sunset in order to avoid diurnal behavior of the fish. A one meter pole with 10cm black and white stripes should be mounted in a manipulator arm in front of the pilot's view. This pole will help the pilot visualize the 2m wide belt in which all fish encountered are identified and measured. The 10cm stripes assists the pilot in estimating the length of the fish. In between transects, the submersible should sit on the bottom with thrusters and lights off for 10 minutes. When the lights are turned back on a qualitative assessment of light effects on fish behavior can be made prior to initiating a new transect.

Advantages and Disadvantages

The Recon/Census Method allows a pilot to conduct comprehensive surveys of selected locations. There are no specific time constraints. The measure of a reliable site characterization is that the pilot feels confident that he or she has has a clear impression of community composition and will recognize the site as similar or different upon return at a later date. This may take one to several hours, depending on the complexity and size of the features being observed. Another advantage is that the search pattern of the pilot is not constrained. This promotes “hunting,” which has been shown to provide a more complete list of taxa for the site.

Transecting provides a more rigorous approach to quantification of organisms, but may require many more samples to achieve a comprehensive characterization. Also, Pearcy et al. (1989) suggests that most large pelagic fish probably avoid submersibles and quantitative surveys done from submersibles are most useful for surveying fishes closely associated with the sea floor, comparing relative abundance among habitats, and for studying fine scale distribution of fish. Transecting also allows pilots who are not trained scientists to acquire information.

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